§36. Study of Energetic Beam Ion Transport in LHD

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The behaviors of trapped particles are complicated and have relatively large orbit size in the radial direction in heliotrons. These radial motion of trapped particle would enhance the radial transport of energetic ions. Also, because of fast drift motion of energetic ions, the direct convective transport by ∇B-drift of ripple trapped particle would be important in the energetic ions confinement in addition to the diffusive (neoclassical) transport, which plays dominant role in the thermal plasma. Thus, the ripple induced transport of energetic ions is an important issue for the energetic ion confinement in heliotrons.

The fast neutral particle analysis using natural diamond detector (NDD)[1] has been applied to measure the distributions of energetic beam ions generated by NBI heating in LHD. We set the NDD line angle almost parallel to the magnetic field line at the plasma center and up to 40 degrees at the plasma edge. Figure 1 shows the measured count number by NDD for two different time periods of a discharge in LHD (the standard configuration; $R_{ax} = 3.75$m). In this discharge the plasma density increases up to $1.5 \times 10^{19}\mathrm{m}^{-3}$ and, then, decreased to $0.7 \times 10^{19}\mathrm{m}^{-3}$. The beam particle ($E_b = 100$keV) was tangentially injected and slows down to the thermal energy. We can see the nearly linear increase of count number as energy decreases in the higher density case. On the other hand the saturation of the count number is found as energy decreases in the lower density case. The dashed lines show the prediction by 2D Fokker-Planck simulation, where no radial transport effect on beam ion is taken into account. We can see large differences between the experimental and 2D simulation results below about 40keV.

Several reasons can be considered for the difference in count number; e.g. *anomalous transport, strong charge exchange effect, etc.* Among them the radial transport due to the helical trapped particle is plausible for the reason of this difference. To make clear this point we study the ripple induced transport of energetic ions using GNET code[2], where the drift kinetic equation in 5D phase-space is solved in the LHD plasma.

Using the obtained distribution by GNET code we have evaluated the neutral particle number detected by NDD (Fig. 1). We have evaluated for two different density cases, $n_{e0} = 1.0 \times 10^{19}$ and $2.0 \times 10^{19} m^{-3}$, with $T_{e0} = T_{i0} = 1.6$keV. We can see the clear decrease of count number due to the ripple induced transport from the 2D F-P results in both density cases and, because of low collisionality, the stronger decrease is found in the lower density case than in the higher one. Consequently, we obtain the relatively good agreement in both density cases and this indicates the important role of ripple induced transport in the radial transport process in the LHD.

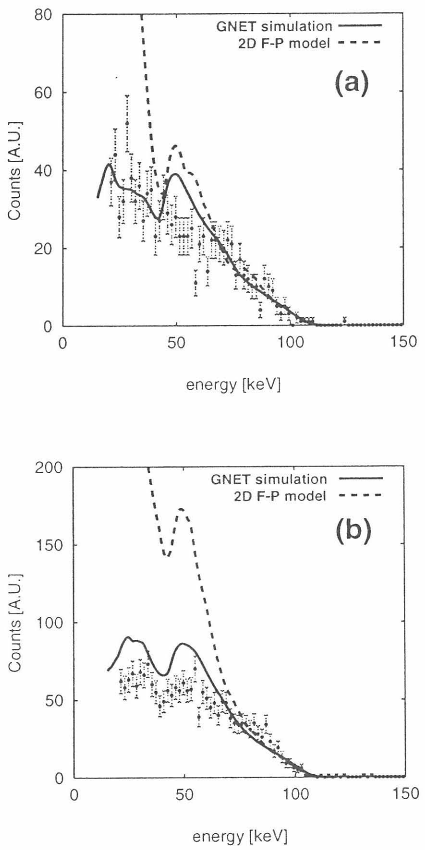

Fig. 1. Plots of the NDD count number with error bars for two different densities; (a) $1.5 \times 10^{19}\mathrm{m}^{-3}$ and (b) $0.7 \times 10^{19}\mathrm{m}^{-3}$. The dashed and solid lines show the predictions by 2D Fokker-Planck calculation and the GNET simulation, respectively.

References

1) Krasilnikov, A., et al., J. Plasma Fusion Res. **75**, (1999) 967.
2) Murakami, S., et al., Nuclear Fusion **40**, (2000) 693.